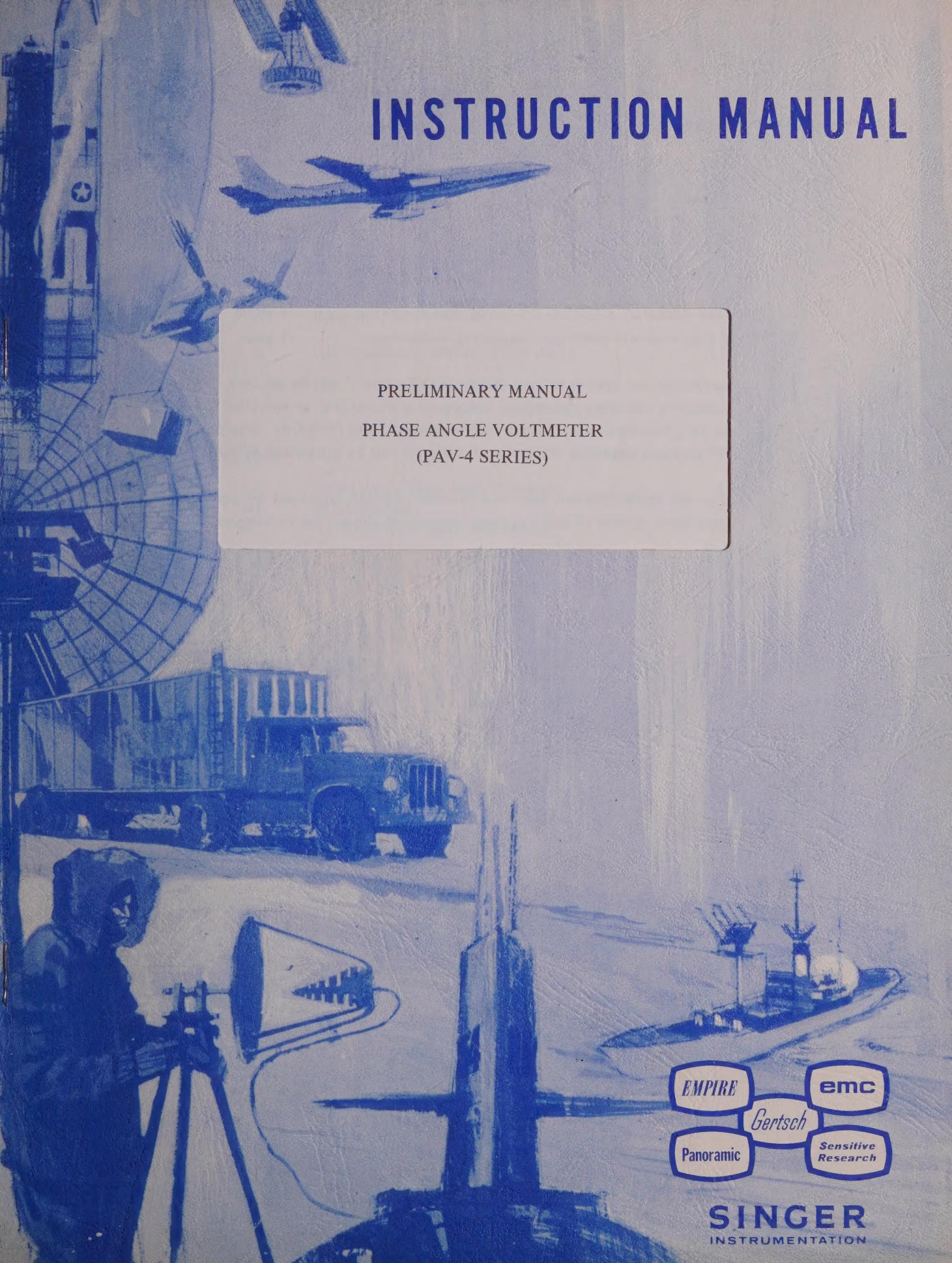
# INSTRUCTION MANUAL

PRELIMINARY MANUAL

PHASE ANGLE VOLTMETER
(PAV-4 SERIES)



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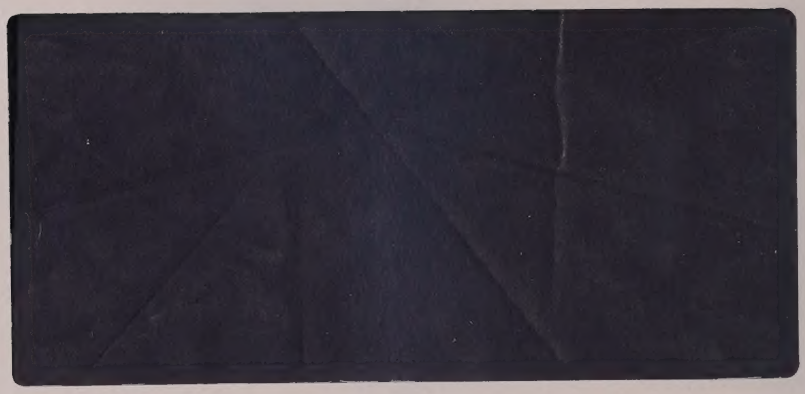

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PHASE ANGLE VOLTMETER
(PAV-4 SERIES)

10/68

SINGER
INSTRUMENTATION

*Precision electrical and electronic instruments for measurement*

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2. Serial Number
3. Description of trouble(2)
4. Test instruments used
5. Approximate date instrument was placed in operation
6. Approximate number of hours of use
7. Has maintenance action been previously requested?
8. Other comments

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument to the factory prepaid. If requested, an estimate of charges will be made before work begins.

(1) Contact Metrics Division, 915 Pembroke St., Bridgeport, Connecticut for *Empire, Panoramic,* and *Sensitive Research* instruments.
Contact Metrics Division, 3211 S. LaCienega Blvd., Los Angeles, California for *Gertsch* instruments.
Contact Metrics Division, 7338 Varna Ave., N. Hollywood, California for *EMC* instruments.

(2) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken, and any other relevant data.

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## FOREWORD

This instruction manual provides operation and maintenance data for the Gertsch Model PAV-4 Series Phase Angle Voltmeters. Sections I through VI cover the basic units, Models PAV-4A and PAV-4B. Sections VII and subsequent provide data on the various plug-in modules used with the basic unit.

The information refers to the standard model listed above and is current only to the date of publication. Differences resulting from the Singer Company's continuous product improvement program are described in addendum sheets. Additional models reflecting customer design and application requirements are described in difference data sheets.

In some cases, part values, ratings and manufacture source are nominal and variations may be found. Satisfactory replacement may be made with either the listed component or an exact replacement of the part(s) removed from the equipment.

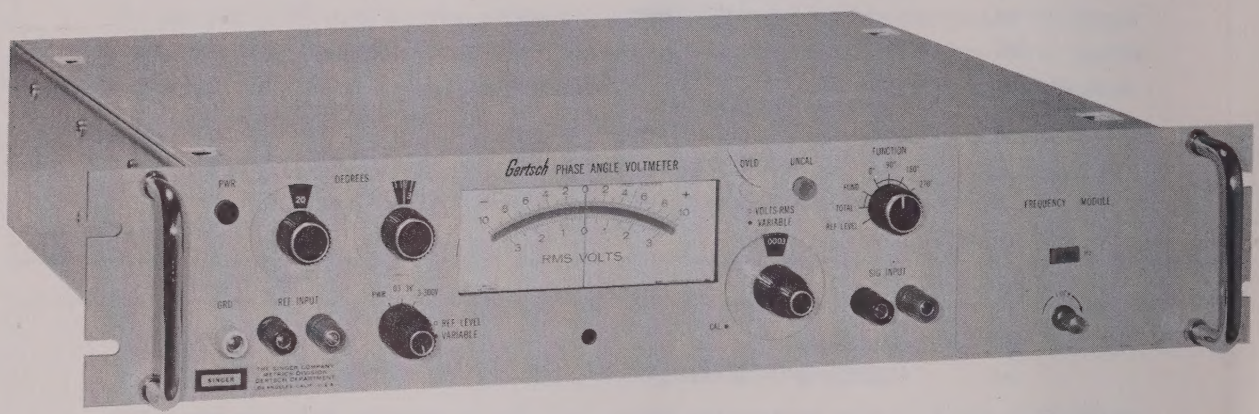


Figure 1-1. Model PAV-4 Phase Angle Voltmeter

# SECTION I
# GENERAL DESCRIPTION

1-1. PURPOSE

1-2. Model PAV-4 Phase Angle Voltmeter combines the capabilities of a standard voltmeter and a phase sensitive voltmeter into a single unit.

a. In combination with Gertsch synchro and resolver test equipment, the Model PAV provides complete checkout capabilities for AC rotating components.

b. In transfer function and filter analysis, the Model PAV provides gain and phase shift readouts on a single panel. Through the use of a variable range control, gain may be displayed as a direct percentage readout.

c. The variable frequency modules use a unique heterodyne system in which the Model PAV is phase locked to an incoming signal. This capability allows the Model PAV-4 to be used for any application which requires pin-point analysis at a unique frequency.

1-3. As a voltmeter, the Model PAV may be used in either of two ways:

a. To measure the total rms voltage of any AC signal in the 30Hz to 1MHz range. With an isolated input (Model PAV-4B), the frequency range is limited to 300Hz to 300KHz.

b. To measure the fundamental rms component of a signal at a selected frequency. In this application, band pass filtering is provided.

1-4. As a phase angle voltmeter, the instrument may be used for a variety of tests in three basic ways:

a. To measure the phase angle between a signal and reference voltage (phase shift through a test piece or system). The Model PAV may be used to measure amplitude at this phase shift angle.

b. To measure the in-phase and quadrature components of the input signal.

c. As a phase sensitive null indicator for extremely accurate bridging circuits. A high tolerance to a quadrature component allows null measurements under a wide variety of conditions. This tolerance is expressed as overload ratio; as noted in the specifications, the quadrature input may be ten times the full scale voltage of the selected range without disturbing the null measurement.

1-5. Front panel controls provide fast changes in mode of operation. In-phase, quadrature, fundamental, and total voltage comparisons may be made without changing the test set-up. The PAV may be switched from use as a sensitive null indicator to measuring absolute voltage magnitude, again without changing a test set-up.

1-6. MODEL DIFFERENCES.

1-7. Model PAV-4A features direct signal and reference inputs with maximum accuracy and the broadest frequency range in the total mode. Model PAV-4B features isolated inputs for measuring differential signals. With either mode, the input impedance is 10 megohms, 20pf, thus minimizing loading effects on a unit under test.

1-8. PLUG-IN MODULES.

1-9. Model SF-1 Single Frequency Module (± 5%) provides an economical approach to production line testing. This module can be supplied with any signal frequency in the 30Hz to 10KHz range.

1-10. Model MF-1 Multiple Frequency Module is similar to the Model SF-1 but can be supplied with up to three frequencies. Operating frequency is selected by a front-panel, three-position switch. Frequency can be changed in the field by changing plug-in components in the module.

1-11. Model VF-1 Variable Frequency Module provides continuous coverage from 300Hz to 10KHz. A unique phase lock circuit eliminates precise tuning; a single tuning control is adjusted until a front panel light indicates phase lock. Remote tuning may also be used with this module.

1-12. Model VF-2 Variable Frequency Module provides continuous coverage from 10KHz to 300KHz. This module is similar to the Model VF-1.

1-13. DESCRIPTION

1-14. The Model PAV is a self-contained test instrument which only requires connection to a 115/230 vac power source. Power conversion is accomplished by selecting a switch setting and changing a fuse value.

## TABLE I. SPECIFICATIONS

| | |
|---|---|
| Voltage Range | 300 μ vrms to 300 vrms in 13 ranges |
| Range Vernier | 100% to 30% without affecting overload ratio |
| Phase Range | -10 to 360 degrees, 0.1 resolution |
| Frequency Range | |
| Total Mode, PAV-4A | 30Hz to 300KHz |
| Total Mode, PAV-4B | 300Hz to 300 KHz |
| Filtered Mode | See Plug-in Module Specifications |
| Accuracy | |
| Voltage, Total Mode | 2% (50Hz to 20 KHz) of f.s.<br>3% (30Hz to 100 KHz) of f.s.<br>5% (100KHz to 300KHz) of f.s. |
| Voltage, Filtered Modes | 2% of f.s. |
| Phase | See Plug-in Module Specifications |
| Input Impedance | |
| Signal | 10M, 25 pf (nominal w/o rear term)* |
| Reference | 10M, 25 pf (nominal w/o rear term)* |
| Input Common to Case Grd, PAV-4B | 200 pf (max w/o rear term)* |
| Reference Input Voltage | 0.03V to 300 vrms |
| Overload Ratio | 10x Full Scale |

| Noise | PAV-4A | PAV-4B |
|---|---|---|
| Total Mode | 20 μV (max) | 30 μV (max) |
| Fund. Mode | 10 μV (max) | 15 μV (max) |
| Phase Angle Modes | 2 μV (max) | 2 μV (max) |

| | |
|---|---|
| Harmonic Rejection | See Plug-in Module Specifications |
| Temperature Range | 0 to 50 degrees C |
| Recorder Output | ± 1 VDC or .3VDC, 1 MADC equals f.s. single-ended |
| AC Amplifier Output | 200MVRMS (approx) equals f.s. single-ended |
| Power | 115/230V ± 10%, 50-400 Hz |
| Size | 3½"H x 19"W x 14"D |
| MODEL SF-1, MF-1 | Plug-in Modules |
| Frequency Range | 30 Hz to 10 KHz |
| Bandwidth | ± 5% |
| Phase Accuracy | 0.5 degrees over entire frequency range. |
| Phase T/C | 0.004 degrees/degree C |
| Harmonic Rejection | |
| Fund. Mode | 45 db (3rd harmonic and above) |
| PAV Mode | 55 db |
| MODEL VF-1, VF-2 | Plug-in Modules |
| Frequency Range | 300 Hz to 10 KHz (VF-1)<br>10 KHz to 300 KHz (VF-2) |
| Bandwidth | Phase-locked to input reference |
| Phase Accuracy | (0.5 + 0.01f KHz) degrees |
| Phase T/C | 0.004 degrees/degree C |
| Harmonic rejection | 2nd > 40 db<br>3rd >55 db |

*Add 45 pf for rear terminals

1-15. All operating controls, indicators, and connectors are mounted on the front panel. Back panel connections include the following:

a. A DC voltage or current output for driving a recorder or an eternal "go," "no-go" control system.

b. An AC amplifier output.

NOTE

The amplitude of both the above outputs is directly related to the voltage indication.

c. The remote tuning input for the variable frequency modules.

# SECTION II
# INSTALLATION

2-1. UNPACKING

2-2. No special handling or unpacking procedures are required. After unpacking, inspect unit for any evidence of damage.

2-3. MOUNTING

2-4. The unit is designed for standard 19" rack mounting however, mounting is not required and the unit may be used as a portable unit.

2-5. ELECTRICAL CONNECTIONS.

2-6. Determine voltage of power source (115 or 230 vac). Set slide switch A5S1 (located on the Power supply and regulator board) to appropriate position and select fuse F1 for power source (115 vac use 1/4 amp fuse, 230 vac use 1/8 amp fuse). The unit is set for 115 vac power when shipped from the factory, unless otherwise indicated.

2-7. INSTALLATION CHECKOUT

2-8. The calibration procedure included in Appendix A may be used as an acceptance test procedure.

## SECTION III
## OPERATING INSTRUCTIONS

3-1. PHASE ANGLE MEASUREMENT.

a. Check mechanical zero of meter. Reset if required.

b. Connect reference input voltage to REF INPUT binding posts.

c. Connect signal input (output of device under test) to SIG INPUT binding posts.

d. Turn REF LEVEL switch cw from PWR position. The PWR indicator should light.

e. Set VARIABLE control associated with VOLTS-RMS switch to the CAL position. Make certain the UNCAL indicator is not lit.

f. Set FUNCTION switch to the REF LEVEL position.

g. Adjust REF LEVEL and associated VARIABLE control as required to obtain a meter deflection to the REF LEVEL mark.

h. (1) If multiple frequency module is used, set FREQUENCY switch to the required frequency.

(2) If variable frequency module is used, adjust frequency control until lock indicator is lit.

i. Set FUNCTION switch and DEGREES controls to 0 degrees.

j. Adjust FUNCTION switch and DEGREES controls to obtain a maximum indication to the right on the meter. First set FUNCTION switch to the 0 degree position and then adjust DEGREES switch through its entire range. If the meter does not indicate a positive (to the right) peak deflection, turn FUNCTION switch to the 90 degree position and repeat adjustment of DEGREES switch. Adjust VOLTS-RMS (range) switch as required.

k. Turn FUNCTION switch 90 degrees in either direction from the position at which maximum positive meter deflection was obtained.

l. Adjust DEGREES controls to obtain an exact null on the meter. For more sensitive null indications, the VOLTS-RMS (range) switch may be turned to lower ranges until the OVLD lamp lights. When the light does light, use the next higher range. When an exact null is obtained, return the VOLTS-RMS range selector to original position.

m. With FUNCTION switch in the position (0, 90, 180, 270 degrees) which gives a meter deflection to the right (+), the phase angle between the signal and input reference voltages is equal to the angular position of the FUNCTION selector plus the dial indications of the 10 and 1 DEGREES controls. The total amplitude of the vector is indicated by the meter (if the VARIABLE range control is in the calibrated position).

3-2. IN-PHASE AND QUADRATURE COMPONENT MEASUREMENTS.

a. Adjust instrument as outlined in steps a through h of paragraph 3-1.

b. To measure the in-phase component, turn the FUNCTION switch and DEGREES controls to the 0 degree position. The meter will then indicate the amplitude of the quadrature component.

c. To measure the quadrature component, turn FUNCTION switch to the 90 degree position and DEGREES controls to the 0 degree position. The meter will then indicate the amplitude of the quadrature component.

NOTE

For more accurate measurement, the VOLTS-RMS (range) switch may be turned to lower ranges until the OVLD light lights. If the light does light, use the next higher range.

3-3. VARIABLE CONTROL USE. If a full scale meter reading, other than those available through use of the VOLTS-RMS (range) switch is desired, adjust the VARIABLE control as follows:

a. Apply a signal with the required full scale amplitude to SIGNAL binding posts.

b. Turn FUNCTION switch to the desired position.

c. Starting with the highest range, turn VOLTS-RMS (range) switch to the first position which causes an off-scale meter indication.

d. Adjust VARIABLE range control until the meter indicates full scale deflection. The UNCAL light will light when the VARIABLE range control is turned from the CAL position.

3-4. NULL INDICATOR USE. To use the instrument as a phase sensitive null indicator, proceed as follows:

a. Adjust instrument as outlined in steps a through h of paragraph 3-1.

b. Determined the phase angle of the axis along which a null is desired. This angle will be determined by the application.

c. Set the sum of the FUNCTION selector and the DEGREES dials to equal the angle in step a above.

d. Adjust the unit under test (or external test equipment) until the meter indicates zero voltage (null).

e. To measure the quadrature voltage at null, turn FUNCTION switch 90 degrees from its initial setting in either direction.

NOTE

If an "error" signal is in-phase with the reference angle selected the deflection will be + and ~~+~~ if it is out-of-phase.

3-5. TOTAL VTVM OPERATION. To measure the total rms voltage of an incoming signal, proceed as follows:

a. Check mechanical zero of meter. Reset if required.

b. Turn REF LEVEL switch clockwise from the PWR position. The PWR indicator should light.

c. Make certain that VARIABLE range control is in the CAL position.

d. Connect input signal to SIG INPUT binding posts.

e. Turn FUNCTION switch to TOTAL position.

f. Turn VOLTS-RMS (range) switch to the lowest range which provides an on-scale reading.

3-6. FUNDAMENTAL VTVM OPERATION. To measure the fundamental rms component of an incoming signal (less noise and harmonics), proceed as follows:

a. Check mechanical zero of meter. Reset if required.

b. Turn REF LEVEL switch clockwise from the PWR position. The PWR indicator should light.

c. Make certain that the VARIABLE range control is in the CAL position.

d. Connect input signal to SIGNAL binding posts.

e. If variable frequency module is used, adjust instrument as outlined in step a through h of paragraph 3-1.

f. If multiple frequency module is used, turn FREQUENCY switch to the selected frequency.

g. Turn FUNCTION switch to FUND position.

h. Turn VOLTS-RMS (range) switch to the lowest range which provides an on-scale reading.

3-7. EXTERNAL CONNECTIONS.

3-8. VDC OUTPUT. To drive a recording device with a DC voltage, connect recorder between 1VDC (pin 3) and GRD (pin 5) terminals of the back panel terminal board. This output may be adjusted with the VARIABLE control (paragraph 3-3).

3-9. DC CURRENT OUTPUT. To drive a recording device or an external relay with DC current, remove jumber and connect device between 1MADC (pin 2) and GRD (pin 1) terminals of the back panel terminal board. This output may be adjusted with the VARIABLE control (paragraph 3-3). Replace jumber when device is disconnected.

3-10. VAC OUTPUT. To use the AC voltage output, connect device between AC out (pin 4) and GRD (pin 5) terminals of the back panel terminal board. This output may be adjusted with the VARIABLE control (paragraph 3-3).

3-11. EXTERNAL TUNING. To provide external tuning of the variable frequency module, disconnect jumber and connect a potentiometer between the VDC EXT IN (pins 6 and 7) terminals of the back panel terminal board. Set the frequency control of the module to maximum frequency. Zero resistance of the external potentiometer equals maximum frequency. Frequency decreases as resistance increases. Replace jumber when potentiometer is disconnected.

TABLE 3-1. CONTROLS AND INDICATORS

| PANEL MARKING | TYPE OF CONTROL | FUNCTION |
|---|---|---|
| PWR | Indicator Light | ON-OFF power indicator |
| DEGREES:<br>10 degree Steps<br>1 degree<br>Markings | Switch<br><br>Variable Resistor | Calibrated phase shifter. Adjusts the phase angle of the reference voltage as required to equal any phase angle within the set quadrant. The readings of these two dials plus the angular setting of the FUNCTION switch indicates the total phase angle<br>FUNCTION = 90 degrees<br>+ DEGREES switch = 20 degrees<br>+ DEGREES resistor = 7 degrees<br>Total phase angle = 117 degrees |
| RMS Volts | Meter | Zero center meter indicates rms voltage or nulls. |
| OVLD | Indicator light | Lights to indicate that the total input signal voltage exceeds the selected range by a factor of 10. |
| UNCAL | Indicator light | Lights to indicate that the VARIABLE range control has been rotated from the CALIBRATED position. Under these conditions, the meter does not indicate full scale voltages equal to the VOLTS-RMS switch settings. |
| FUNCTION | Rotary Switch | REF LEVEL – switches circuitry to meter and adjust reference input level. |
| | | TOTAL – switches circuitry to measure total rms value of the input signal. |
| | | FUND – Switches circuitry to measure fundamental rms component of the signal. |
| | | 0, 90, 180, 270 Degrees – Calibrated phase shifter used in conjunction with DEGREES controls. Adjusts phase angle of reference voltage for phase sensitive measurements. |
| SIG INPUT | Binding Posts<br>(Red – HI)<br>(Black – LO) | Input signal connection point. |
| VOLTS-RMS | Rotary Switch | 13 position range control selects full-scale voltage range of instrument. |
| VARIABLE | Variable resistor | Adjustable attenuator provides a variable meter scale factor (an arbitrary input signal may be set for a full-scale meter indication. with the meter scale then used for direct percentage readouts). |
| REF LEVEL<br>VARIABLE | Rotary switch<br>Variable resistor | Adjusts reference channel to the amplitude level of the reference input. Also functions as power on-off control. |
| REF INPUT | Binding Posts<br>(Red – HI)<br>(Blank – LO) | Reference input connection point. |
| GRD | Binding Post. | Instrument case ground. |

TABLE 3-1. CONTROLS AND INDICATORS (CONT)

| PANEL MARKING | TYPE OF CONTROL | FUNCTION |
|---|---|---|
| NOTE: The following connections are located on the back panel. | | |
| 1MADC | Terminal Board | Current output, analog of meter reading. |
| 1VDC | | DC voltage output, analog of meter reading. |
| AC Out | | AC voltage output, analog of meter reading. |
| VDC EXT IN | | Provides external tuning of the variable frequency modules. |
| SINGLE FREQUENCY MODULE | | |
| None | | |
| MULTIPLE FREQUENCY MODULE | | |
| Frequency | 3-position rotary switch | Select frequency for fundamental, or phase sensitive modes of operation. |
| VARIABLE FREQUENCY MODULE | | |
| – – | Variable Resistor | Tunes module to operating frequency (fundamental and phase sensitive modes) |
| LOCK | Indicator Light | Lights to indicate that module is tuned to frequency. |

3-12. NOTES ON OPERATION.

3-13. GROUND LOOPS. Ground loops should be avoided particularly when the unit is used as a phase sensitive voltmeter. To avoid ground loops (with PAV-4A), use isolation transformers (Gertsch Model ST103 and ST102 respectively, or equivalent) in the signal and reference input circuits.

3-14. BEAT NOTES. If the power and reference voltage have the same frequency, the two sources must be phase locked. Any difference in frequency can result in beat notes which, in turn, cause erroneous voltage indications.

3-15. DETECTOR CIRCUIT. The VTVM detector circuit is an average responding circuit, calibrated to indicate rms value. When a square wave is applied (or a pulsating DC signal), the average-to-rms values change and therefore a correction factor must be applied to the meter reading:

a. In the total mode, the meter reading is 1.11 times the peak value of the square wave input. A 100V peak-to-peak square wave will read 111 vrms.

b. In the fundamental mode, the meter reading is 0.9 times the peak value of the square wave input. A 100V peak-to-peak square wave will read 90 vrms.

## SECTION IV
## THEORY OF OPERATION

### 4-1. GENERAL THEORY

4-2. The signal circuitry, shown in the top section of the block diagram (figure 4-1) provides the range control circuitry and amplification for the signal input. The reference circuitry, shown in the bottom section of the block diagram, converts the reference input signal to the proper reference signal for the phase sensitive detector.

4-3. STANDARD VOLTMETER. When the instrument is used as a standard voltmeter, the reference circuitry is switched out and a full-wave rectifier is used as the meter detector. In the total function, the signal circuit is broad band and therefore the total incoming signal is applied to the meter circuit. The meter circuit is an average measuring circuit but the meter is calibrated to indicate rms value. In the fundamental function, band pass filtering is switched into the signal circuit to minimize noise and harmonics. Under these conditions, the meter indicates the fundamental rms value of the incoming signal.

4-4. PHASE ANGLE VOLTMETER. When the instrument is used as a phase angle voltmeter, a phase sensitive bridge circuit is used as the meter detector. The reference circuit is switched into the system and supplies a reference signal with an adjustable phase angle to the bridge. The input and reference signals are compared in the phase sensitive bridge. When the phase angle of the detector reference signal is adjusted to exactly equal the phase angle of the input signal, the detector output is maximum. Since a filter is switched into the signal channel, the meter indicates the fundamental rms value of the signal input.

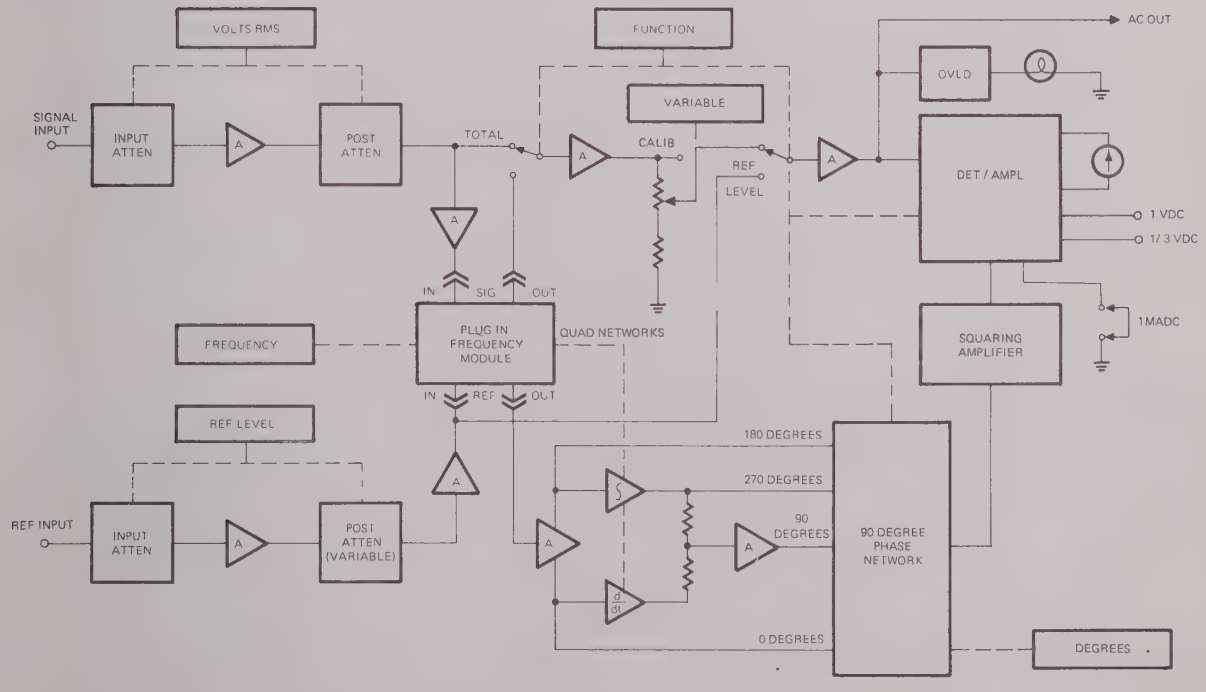


Figure 4-1. Block Diagram

4-5. If there is a phase shift through a unit under test, the output signal as related to the input signal contains two components: an in-phase component (X) and a quadrature component (jY). As shown in Figure 4-2, the phase angle is determined by the relative amplitudes of the components and by the arithmetical signs (plus or minus). At 45 degrees, the amplitudes are equal and both components have a plus sign. At 225 degrees, again the amplitudes are equal, but both components have a minus sign;

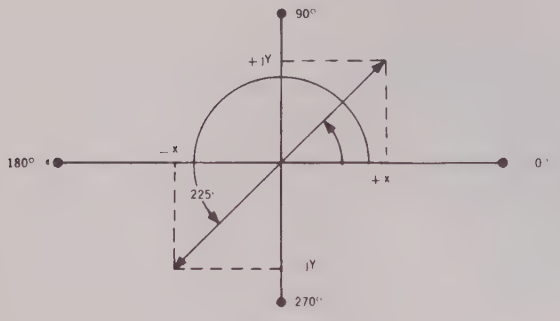


Figure 4-2. Input to Output Signal Relationships

4-6. The reference circuitry uses the reference input signal to generate the detector reference signal. The in-phase portion (X) is obtained by using the reference signal without change. The quadrature portion is obtained by shifting the phase of the reference voltage 90 degrees in a quadrature generator. The two components are combined in the phase angle network.

4-7. PHASE ANGLE NETWORK. A specific phase angle is selected by three controls: the function switch, the 10° DEGREES switch, and the interpolating potentiometer as shown in Figure 4-3. The function switch operates as the quadrant selector and places the proper in-phase (0 or 180 degree) and quadrature (90 or 270 degree) voltages across the 10 degree resistor network.

4-8. The degrees switch S4 positions the interpolating potentiometer within a resistor network. The network has an in-phase component applied to one end and a quadrature component applied to the other. At the midpoint of the network, the two components are equal. If both components have a plus sign, the midpoint equals a phase angle of 45 degrees. The resistance of the potentiometer provides a 10 degree span and may be placed within the network to provide coverage over a 10 degree span within the 90 degree quadrant.

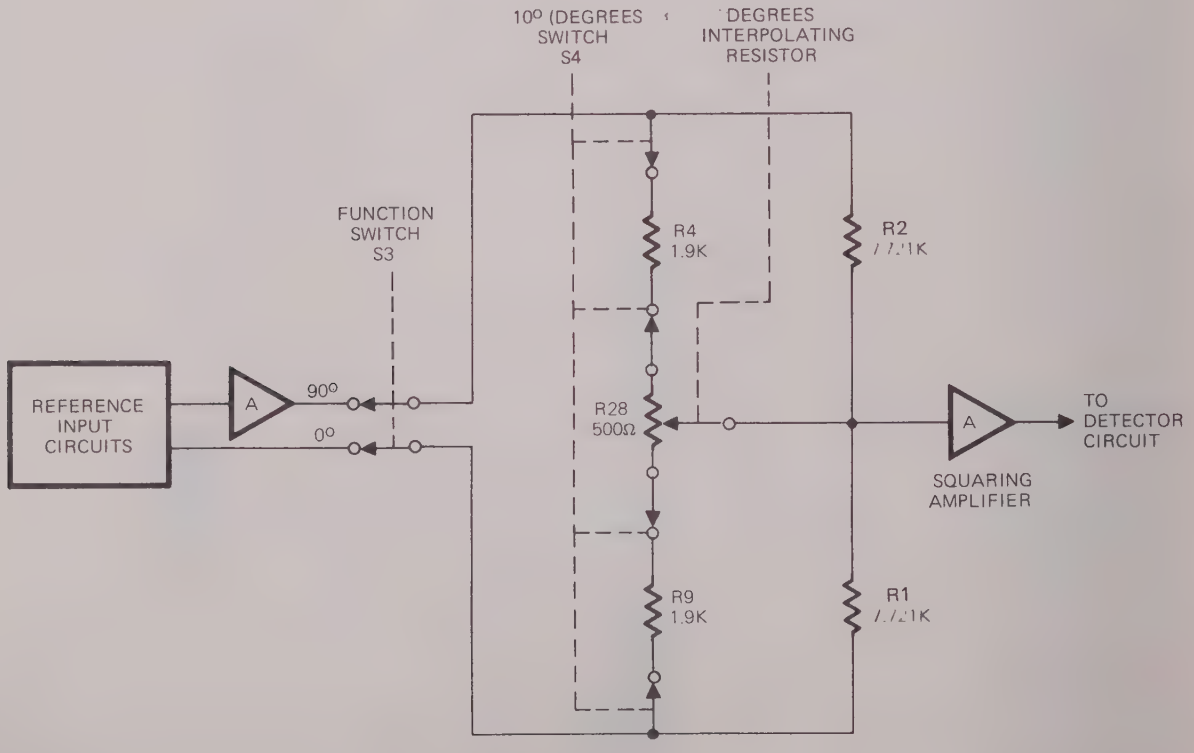


Figure 4-3. Phase Angle Network

4-9. FREQUENCY MODULES.

4-10. SINGLE FREQUENCY MODULE. This module provides a band pass filter for the signal channel, a band pass filter for the reference channel, and tuning components for the quadrature generators. These components provide fixed-frequency operation.

4-11. MULTIPLE FREQUENCY MODULE. This module is similar to the single frequency module except that three sets of components are included.

4-12. VARIABLE FREQUENCY MODULE. The input signal and reference voltages are mixed with outputs of an oscillator to provide IF frequencies (see figure 4-4). The IF frequencies are then filtered and delivered to the PAV circuits.

4-13. The mixer frequency is provided by a DC voltage controlled oscillator. This oscillator is tuned by a variable potentiometer (frequency control) and the output of a phase detector. A highly stable, IF oscillator provides a comparison frequency for the phase detector. A second phase detector provides an output for the lock light.

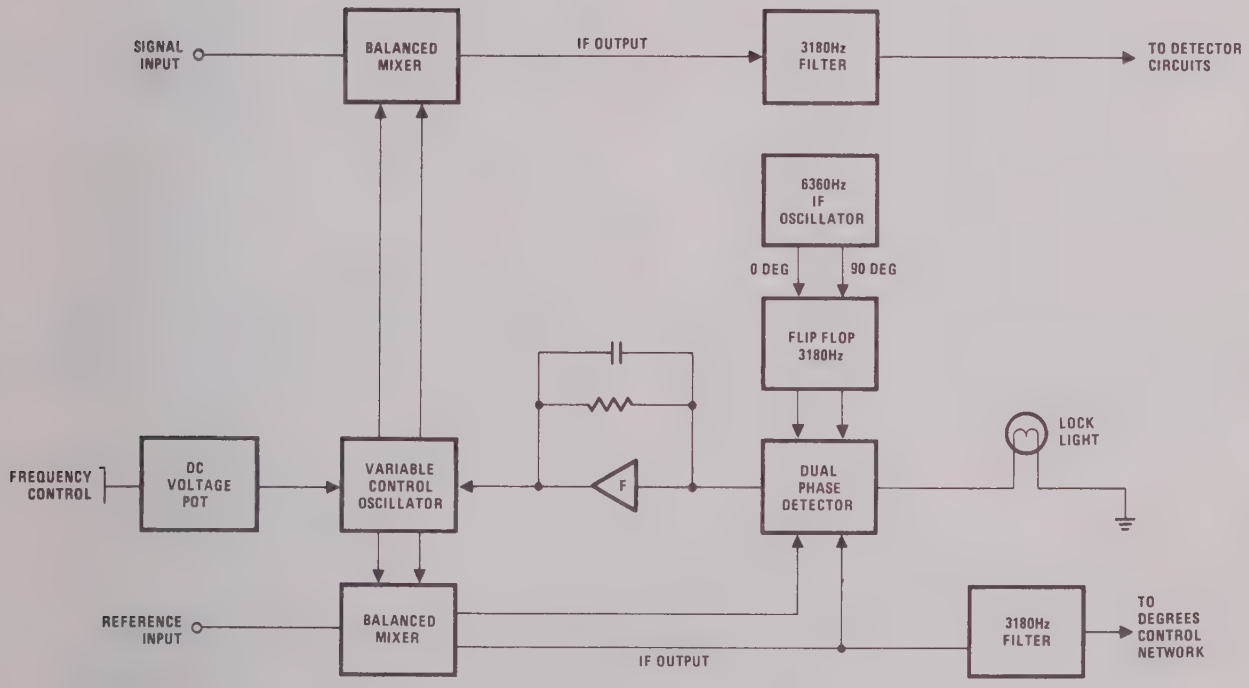


Figure 4-4. Variable Frequency Module

# APPENDIX A
# APPLICATION DATA

## A-1. BRIDGE CIRCUIT APPLICATION.

A-2. In a bridge circuit, the phase angle voltmeter operates as a phase sensitive null detector with a high tolerance to a quadrature component. The PAV may be combined with any Gertsch RatioTran to form the AC bridge circuit shown in figure A-1.

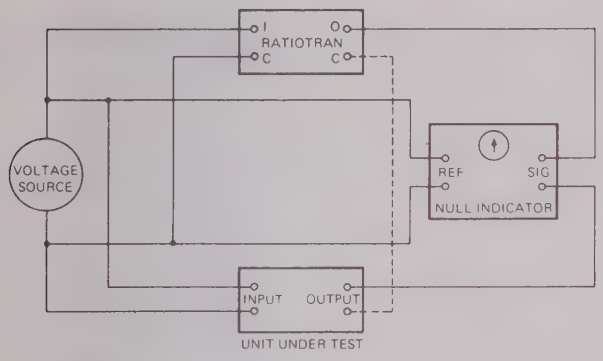


Figure A-1. AC Bridge Circuit

A-3. In this circuit, the PAV is set to 0 degree for detection of in-phase nulls. The RatioTran is adjusted until null is obtained. The in-phase, input-to-output voltage ratio of the unit under test may be read directly from the settings of the RatioTran.

3A-10. The range control (VOLTS-RMS) of the PAV functions as a sensitivity control. If noise, harmonics, etc., obscure the null point, a higher range may be used. For more precise measurements, the lower ranges may be used.

A-4. The variable control of the PAV may be used for "go" "no-go" measurements. A typical procedure is as follows:

a. Obtain an exact null at a selected reference point (0 degree output of unit-under-test, output at center frequency or center position of unit-under-test).

b. Determine largest allowable deviation from this ratio setting. Offset the RatioTran by this amount.

c. Through the use of the variable control, set this off-null voltage to equal a full-scale meter reading.

d. Reset the RatioTran to the null point.

e. In subsequent readings, any off-scale reading indicates "no-go". Any on-scale reading may be read as a direct percentage error.

A-5. The quadrature component of a phase-shifted signal can overload the signal circuits of the PAV and obscure the in-phase null. Assume an output vector voltage of 100 volts rms and phase a shift of 0.01 degrees. The sine of 0.01

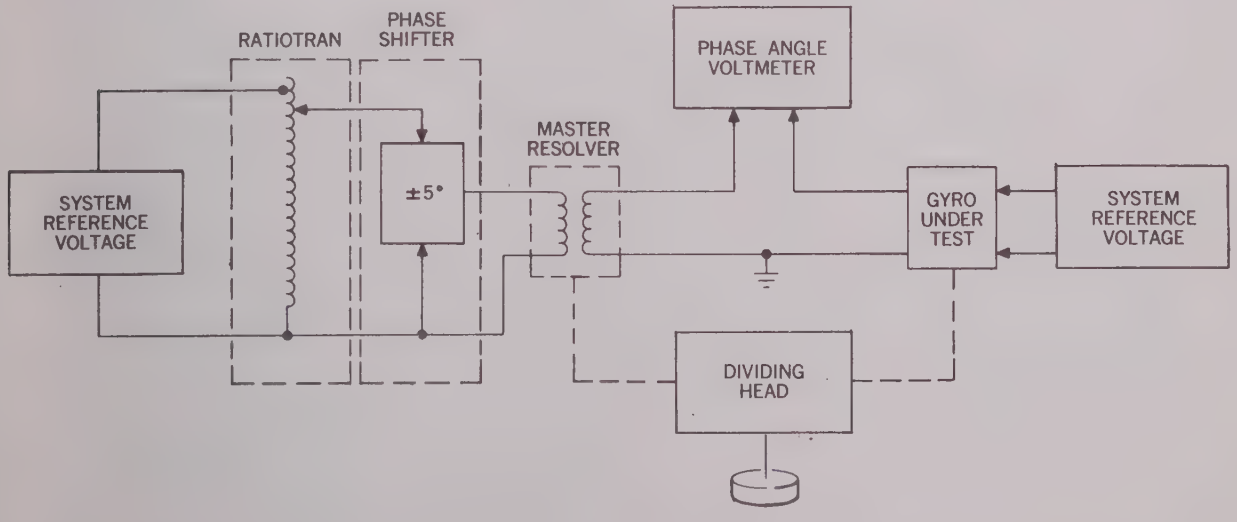


Figure A-2. Modified Bridge Circuit

degrees is 0.00017; 100 x 0.00017 results in a quadrature component of 17 millivolts. With the PAV operating in the 300uv or 1 millivolt range, this 17 millivolts represents an overload condition. The OVLD indicator would light although the meter would indicate null or near null. By switching to a higher range (less sensitivity), a more clearly defined null indication may be obtained.

A-6. Once null is obtained, a complete analysis of the output of the device under test may be made. The PAV may be operated in the 90 degree or FUND mode to measure quadrature voltage output. The PAV may be operated in the TOTAL mode to measure quadrature plus harmonic plus noise output.

A-7. MODIFIED BRIDGE CIRCUITS.

A-8. A typical modification of the bridge circuit is shown in figure A-2. In this circuit, the output of a gyro is compared against the output of a master resolver (null equals no error).

A-9. To compare the two units, some slight correction for phase shift and transformation ratio (RatioTran) are made. In this application the PAV is set to an angle equal to the phase shift through the master resolver.

A-10. Another modified bridge circuit is shown in figure A-3. This circuit is used to measure the functional accuracy of a computational resolver.

A-11. Functional accuracy is a measure of the accuracy with which a computational resolver computes a trigonometric equation. This accuracy is generally expressed as a percentage of the output at the point of maximum coupling. The output of a .1% computational resolver is maximum at 90 degrees for the sine function. The accuracy is therefore .001 times the voltage ($E_S$ MAX) at 90 degrees ($\sin \theta = 90^o$).

A-12. A dividing head is the precision angular positioning device used to mechanically rotate a unit under test. A resolver standard produces a $\sin \theta$ reference voltage to measure the computed output of the unit under test. All components may be tested at 5 degree increments throughout the 0 to 360 degree range.

A-13. The decade capacitor and the 1K resistor are used to compensate for any phase shift through the unit under test. These components are used to shift the phase of the reference input to the phase angle voltmeter and the resolver standard. The RatioTran by the same process compensates for any variation in transformation ratio through the unit under test.

A-14. SYNCHROS AND RESOLVERS

A-15. Most angular accuracy tests of synchros and resolvers use a bridge circuit which requires a phase sensitive null indicator, equipped with a calibrated phase shifter. The variable control is particularly useful when checking the output at 5 degree increments throughout the 360 degree range of the component. Null voltage readings may be made by switching the PAV to the fundamental or total modes. Transformation ratio may be determined with a RatioTran as shown in figure 3A-1. The calibrated phase shifter provides a readout of phase shift ($\theta$) of the unit-under-test.

A-16. TRANSFER FUNCTION TESTS.

A-17. A typical transfer function test set-up is shown in Figure A-4.

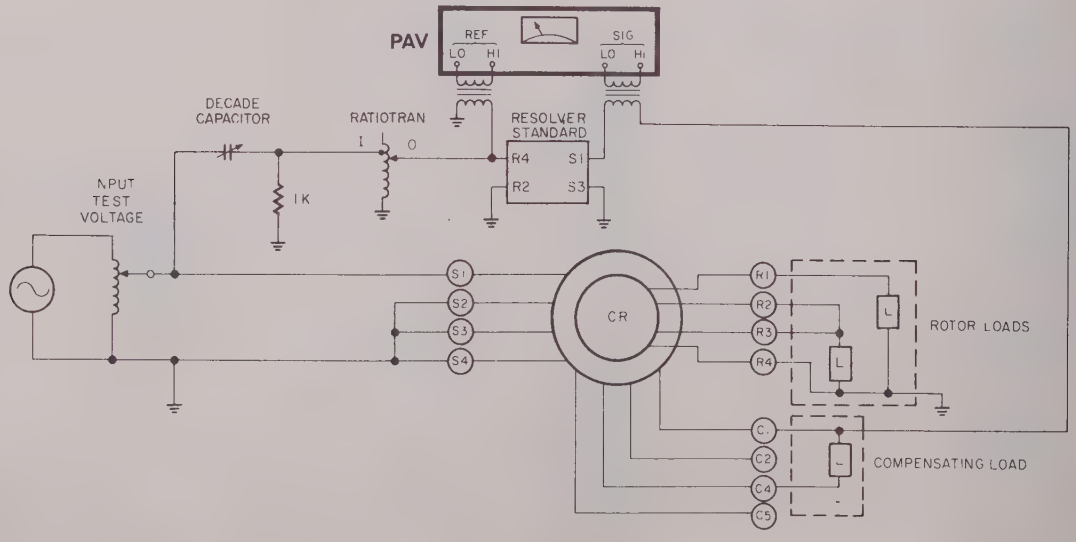


Figure A-3. Functional Accuracy Test

In this application, the PAV measures absolute amplitude at a selected frequency and phase angle (instead of detecting nulls). For point-by-point frequency response measurements, a variable frequency module is required. The RatioTran provides very precise changes in input level.

A-18. A specific frequency and amplitude level are used to establish nominal gain and phase shift through the device under test. Phase shift may be measured as outlined in paragraph 3-1 and gain may be measured in the phase sensitive or fundamental modes. The nominal gain may then be set for full scale indication as outlined in paragraph 3-3. Subsequent indications may then be read as a direct percentage figure.

A-19. This same technique may be used for transformer tests, filter analysis, transducer tests, etc.

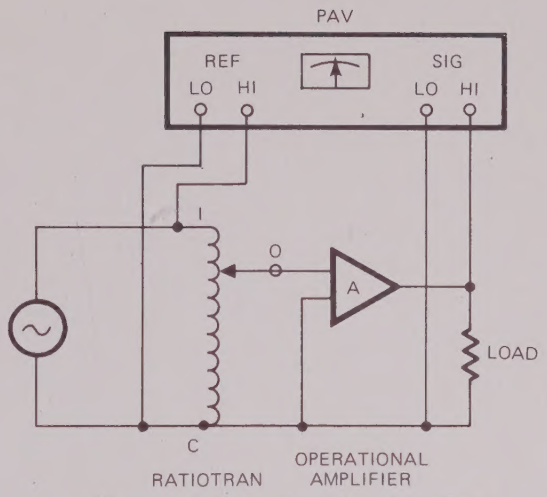

Figure A-4. Operational Amplifier Test

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